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ABSTRACT

Position statements of the National Council of Teachers of Mathematics (NCTM) are provided in detail. Topic areas for which position statements are provided include: Calculators and the Education of Youth, Early Childhood Mathematics Education, Evaluation of Teacher Performance, Guiding Students' Attitudes and Decisions Regarding Their Mathematics Education, Mathematics Education of Underrepresented Groups, Mathematics for Language Minority Students, Mathematics Leaders in Elementary/Middle Schools, Mathematics Leaders in Secondary Schools, Metrication, Professional Development of Teachers of Mathematics, Professional Standards for Selection and Implementation of Instructional Materials, Teaching Mathematics in the Middle Grades, and the Use of Technology in the Learning and Teaching of Mathematics. (DDR)

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Position Statements of the National Council of Teachers of Mathematics

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Calculators and the Education of Youth

Calculators are widely used at home and in the workplace. Increased use of calculators in school will ensure that students' experiences in mathematics will match the realities of everyday life, develop their reasoning skills, and promote the understanding and application of mathematics. The National Council of Teachers of Mathematics therefore recommends the integration of the calculator into the school mathematics program at all grade levels in classwork, homework, and evaluation.

Instruction with calculators will extend the understanding of mathematics and will allow all students access to rich, problem-solving experiences. This instruction must develop students' ability to know how and when to use a calculator. Skill in estimation and the ability to decide if the solution to a problem is reasonable are essential adjuncts to the effective use of the calculator.

Evaluation must be in alignment with normal, everyday use of calculators in the classroom. Testing instruments that measure students' understanding of mathematics and its applications must include calculator use. As the availability of calculators increases and the technology improves, testing instruments and evaluation practices must be continually upgraded to reflect these changes.

The National Council of Teachers of Mathematics recommends that all students use calculators to—

- explore and experiment with mathematical ideas such as patterns, numerical and algebraic properties, and functions;
- develop and reinforce skills such as estimation, computation, graphing, and analyzing data;
- focus on problem-solving processes rather than the computations associated with problems;
- perform the tedious computations that often develop when working with real data in problem situations;
- gain access to mathematical ideas and experiences that go beyond those levels limited by traditional paper-and-pencil computation.

The National Council of Teachers of Mathematics also recommends that every mathematics teacher at every level promote the use of calculators to enhance mathematics instruction by—

- modeling the use of calculators in a variety of situations;
- using calculators in computation, problem solving, concept development, pattern recognition, data analysis, and graphing;
- incorporating the use of calculators in testing mathematical skills and concepts;
- keeping current with the state-of-the-art technology appropriate for the grade level being taught;
- exploring and developing new ways to use calculators to support instruction and assessment.

The National Council of Teachers of Mathematics further recommends that—

- school districts conduct staff development programs that enhance teachers' understanding of the use of appropriate state-of-the-art calculators in the classroom;
- teacher preparation institutions develop preservice and in-service programs that use a variety of calculators, including graphing calculators, at all levels of the curriculum;
- educators responsible for selecting curriculum materials make choices that reflect and support the use of calculators in the classroom;
- publishers, authors, and test and competition writers integrate the use of calculators at all levels of mathematics;
- mathematics educators inform students, parents, administrators, and school boards about the research that shows the advantages of including calculators as an everyday tool for the student of mathematics.

Research and experience have clearly demonstrated the potential of calculators to enhance students' learning in mathematics. The cognitive gain in number sense, conceptual development, and visualization can empower and motivate students to engage in true mathematical problem solving at a level previously denied to all but the most talented. The calculator is an essential tool for all students of mathematics.

(February 1991)

Early Childhood Mathematics Education

The National Council of Teachers of Mathematics believes that early childhood mathematics education, for young children aged 3–8, should be developmentally appropriate. Developmentally appropriate instructional practices are those in which the mathematics learning environment takes into account the social, emotional, physical, and intellectual needs of young children. Since young children actively construct knowledge, instruction should concentrate on facilitating learning through exploration and interaction with materials and people. In early childhood mathematics, how and when the curriculum is taught is as important as what is taught. Thus, endorsing a developmental philosophy for early childhood mathematics education suggests reorganizing classroom practices around the total child rather than allowing materials and rigid time lines to dictate instruction. Furthermore, early childhood mathematics instruction should foster a positive environment, provide equal access for all children, and account for cultural and ethnic diversity.

Therefore, the National Council of Teachers of Mathematics recommends developmentally appropriate curriculum and evaluation guidelines for early childhood mathematics instruction that have the following aims:

- Acknowledge and build on children's accumulated knowledge by including children's experiences, language, and relevant real-world contexts.
- Incorporate active and interactive learning. Children's understandings develop as they explore, investigate, and discuss mathematical concepts. Physical and mental interactions with the environment, materials, and other individuals give children opportunities to construct, modify, and integrate their ideas.
- Offer opportunities for children to develop and expand language acquisition while structuring, restructuring, and connecting mathematical understandings. Concepts should be repeatedly experienced through concrete, visual, verbal, and pictorial formats. Gradually, children should be encouraged to translate and record their experiences in more abstract representations.
- Be concept and problem solving oriented. The classroom environment should provide for the regular study of mathematics focusing on the development and integration of mathematical thinking, reasoning, understandings, and relationships through concrete problem-solving experiences. Mathematical concepts should be integrated with other subject areas, making use of natural connections wherever they occur.
- Develop children's confidence in their mathematical abilities. Varied instructional strategies, meaningful child-related contexts, and opportunities for active participation in the learning process encourage children to become capable mathematical thinkers and to believe in themselves as such.
- Include ongoing assessment. Teachers should make instructional decisions that are based on the progress of the children in their classroom. Children's progress is determined through information obtained from formal and informal assessment of each child's individual pattern of growth. Evaluation strategies such as observations, interviews, and portfolios give evidence of children's thinking processes and their understanding of concepts.

The National Council of Teachers of Mathematics recommends that those who produce, select, and purchase young children's mathematics curriculum materials support developmentally appropriate early childhood mathematics programs. Guidelines for early childhood mathematics education encourage a child-centered approach to

instruction. Preference should be given to mathematical learning environments that support active participation where children learn through observation, exploration, verbalization, and hands-on experiences. The focus of instruction should be on the continuous development of mathematical processes and language through activities that gradually increase in difficulty, complexity, and challenge as children develop understanding and skills. Developmentally appropriate early childhood mathematics instruction should meet the needs of individual learners at different stages of readiness by considering the influences of cultural backgrounds, prior experiences, learning styles, and cognitive abilities. (February 1991)

Evaluation of Teacher Performance

Increasing demands for accountability have led state and provincial legislatures and agencies, school districts, professional organizations, and teacher education institutions to expand their efforts to evaluate a teacher's knowledge and performance. Although such evaluations are often used as a basis for decisions about admission to teacher education programs, eligibility for certificates, or advancement in the profession, the most important purpose of evaluation is to connect a teacher's current teaching with the professional development necessary to enable that teacher to improve the teaching of mathematics.

Evaluation includes the identification of goals by the teacher and the evaluators, the collection of information, and a collaborative dialogue between the teacher and the evaluators to reformulate, redirect, and refine goals for the future. Goals for personal and professional growth may include some that are mandated by the state or province, district, teacher education institution, or individual school, but the teacher must be an active participant in identifying goals that improve instruction.

A comprehensive picture of both the purpose and the process for the evaluation of teaching is portrayed in the *Professional Standards for Teaching Mathematics*, prepared by the National Council of Teachers of Mathematics in 1991. The process begins by collecting data representative of the teacher's current practice. Data should be gathered from various sources, such as self-assessment, observations, interviews, peers, students, teacher's portfolios, supervisors, and administrators.

The use that is made of the information gained through the evaluation process is as important as the act of evaluation itself. The appropriate outcome of this ongoing process is a collaborative dialogue between the teacher and others involved in the process, resulting in a mutually agreed-on plan for professional growth.

Although the process of evaluating the effectiveness of teachers may be applicable across subjects and grade levels, the specific goals, criteria for observation, and resulting dialogue must be directly related to the content of mathematics and to the teaching strategies.

The evaluation team should have a deep knowledge of the vision of teaching presented in the *Professional Standards for Teaching Mathematics* and rooted in the mathematical content and processes described in the *Curriculum and Evaluation Standards for School Mathematics*. The team should represent expertise and experience in mathematics and the teaching of mathematics as well as in evaluation.

Therefore, the National Council of Teachers of Mathematics recommends that supervisors and administrators work closely with teachers to assure that the evaluation process is used to enhance the professional development of the teacher and increase the effectiveness of mathematics teaching. (April 1993)

Guiding Students' Attitudes and Decisions Regarding Their Mathematics Education

Educators, including parents, teachers, counselors, and administrators, are positioned to influence the formation of students' attitudes toward, and perceptions about, mathematics. These attitudes and perceptions are formed at an early age and reinforced by educators throughout the students' school years.

The following issues should be addressed at all levels:

- Equal access to the world of mathematics regardless of gender, ethnicity, or race
- The broad range of options available to students of mathematics
- That success in mathematics is more dependent on effort and opportunity to learn than on innate ability.

For students to succeed in their study of mathematics, they must believe that they can "do" mathematics and that it is worth "doing." Therefore, the National Council of Teachers of Mathematics believes the following statements should characterize student programs:

Elementary School Level

Young children enter school having natural interest, curiosity, and an eagerness to learn. As children move through the elementary school level, educators build on these attitudes, which support children's mathematical development. By connecting mathematics with real-life experiences, educators can help children not only understand mathematics but see its value and usefulness.

Middle School Level

During the middle school years, students are experiencing the greatest changes in their development. It is during these years that educators must continue to provide encouragement to students and enable them to develop confidence in their ability to make sense of mathematics. A focal point for this age group is making connections between mathematics and their future options so that their academic and work-related choices are kept as broad as possible.

Secondary School Level

At the secondary school level, students should recognize the importance of the relationships between academic choices and career choices. It is essential that educators reinforce students' belief in the value of mathematics, in their ability to "do" mathematics now and in the future, and in their need to continually learn.

In addition, students should continually be provided reliable, up-to-date information on

- how what they are learning in mathematics relates to future options;
- the increasing number of career opportunities that are available as a consequence of further mathematical study;
- how careers in fields other than mathematics and the physical sciences are increasingly dependent on mathematical knowledge;
- their school's graduation requirements in mathematics;
- the entrance and graduation requirements in mathematics for vocational schools, technical schools, colleges, and universities.

Therefore, the NCTM recommends that all educators, including parents, teachers, counselors, and administrators, work together to shape, guide, and inform students' attitudes, perceptions, and decisions regarding their education in mathematics. (February 1994)

The Mathematics Education of Underrepresented Groups

The National Council of Teachers of Mathematics is committed to the principle that groups underrepresented in mathematics-based fields of study should be full participants in all aspects of mathematics education. These groups are composed of students who do not take advanced mathematics courses and do not enter mathematics-related vocations and careers in proportion to their representation in the population. The groups include females, African Americans, Hispanics, Native Americans, Alaskan Natives, and Native Pacific Islanders, among others.

Paths to continuing education and employment opportunities are often hindered by powerful social and institutional influences that discourage these students from studying mathematics. In our challenging and complex society, it is paramount that all students are considered valuable resources to be afforded the opportunity to reach their full potential and contribute to society.

Schools and districts should examine programs including assessment and instructional practices that may lead to mathematics avoidance.

— Mathematics educators must take an individual and collective commitment to eliminate any psychological and institutional barriers to the study of mathematics. Educators must explore and implement innovative ways to convince students and families from these groups of the vital importance of taking mathematics courses.

Teachers, administrators, and counselors at all educational levels should expect that students from all segments of the population will be successful in mathematics. The teacher is in a pivotal position to motivate and encourage all students to continue the study of mathematics.

All students must study a core curriculum in mathematics that reflects the spirit and the content of the NCTM *Standards*. The NCTM will continue to work to increase the participation and achievement of underrepresented groups in mathematics education. (April 1995)

Mathematics for Language Minority Students

Every student is entitled to a mathematics education that provides preparation for a full range of careers having mathematical prerequisites and to be an informed citizen. Cultural background and language must not be a barrier to full participation in mathematics programs.

Therefore, the National Council of Teachers of Mathematics makes the following recommendations:

- All students, regardless of their language or cultural background, must study a core curriculum in mathematics based on the NCTM *Standards*.
- Educators must identify and remove language-based barriers.
- Language minority students must be given appropriate assistance in learning mathematics.
- Counselors and teachers must support and encourage students in continuing their mathematics education.
- The importance of mathematics and the nature of the mathematics program must be communicated to both students and parents.
- The mathematics curriculum must include connections to the cultural heritage of students.
- Teaching and assessment strategies must build upon the cultural heritage and learning styles of students.

To verify that barriers have been removed, educators must monitor enrollment and achievement data to determine whether language minority students have gained access to, and are succeeding in, core mathematics courses. Reviews must be conducted at district, state/provincial, and national levels. (September 1993)

Mathematics Leaders in Elementary/Middle Schools

A key component in the improvement of mathematics instruction for all students is greater attention to the elementary/middle school mathematics program through the provision of stronger mathematics leadership at individual schools.

School mathematics leaders are essential for raising the level of mathematical knowledge and pedagogical competence of the staff, for coordinating mathematics instructional effort within and between buildings, and for helping to assure the implementation of a comprehensive, high-quality program. In addition, school mathematics leaders will support the roles and efforts of teachers, supervisors, and administrators who are increasingly concerned with promoting excellence for their students.

For these reasons, the National Council of Teachers of Mathematics advocates that every elementary/middle school identify a school mathematics leader to provide ongoing leadership and assistance in planning, implementing, and evaluating a comprehensive school mathematics program. School mathematics leaders should be available as a resource to all staff in the areas of curriculum design, professional development, teaching methodology, classroom management, selection of materials, and student assessment.

More specifically, school mathematics leaders may perform or assist in any, or all, of the following tasks connected with the essential instructional functions listed below:

1. Curriculum Design
   a) Provide leadership in the development of mathematics instructional programs to meet diverse student needs
   b) Coordinate the implementation of a sound instructional scope and sequence for mathematics
   c) Facilitate the review and revision of the curriculum
   d) Integrate mathematics with other content areas
2. Curricular Content
   a) Relate the content of state/provincial and local curriculum guidelines to the individual school's program
   b) Present and interpret mathematics content to meet teachers' needs
   c) Promote the importance of mathematics
   d) Keep abreast of national, state/provincial, and local recommendations for updating and revising curricular content by participating in the activities of professional associations
3. Methodology and Materials
   a) Acquaint teachers with successful and innovative strategies for classroom instruction through demonstration lessons and conferences
   b) Consult with teachers in selecting and implementing activities that improve motivation and attitude toward mathematics
   c) Review, and recommend for acquisition when appropriate, teaching materials, calculators, computer software, etc., and assist teachers in integrating them into the program
4. Assessment
   a) Participate in the review and selection of means of assessment
   b) Assist staff in designing and using classroom tests
   c) Assist staff in interpreting and using test data and placing students in appropriate activities
5. Other Functions
   a) Work with staff in determining needs and priorities for professional development
   b) Assist teachers, on request, in self-evaluation activities
   c) Plan and budget for the purchase of instructional materials
   d) Maintain and promote effective communication among grades and schools and with parents, the community, and support personnel
   e) Coordinate instruction between regular and special programs to meet individual student needs
   f) Manage, schedule, and equip a mathematics laboratory or teacher resource room
   g) Provide direct instruction, as appropriate, for individual students, mathematics teams, or special projects

As defined, school mathematics leaders serve as an immediate resource to teachers by demonstrating knowledge, competence, and leadership in mathematics education. Thus, they should know and understand mathematics substantially beyond that which they may be expected to teach, and they should have knowledge and competence in the methods and techniques appropriate for effectively teaching mathematics to elementary/middle school students. (March 1984)

Mathematics Leaders in Secondary Schools

Strong mathematics leadership in each school building is a significant factor in the improvement of secondary mathematics instruction. Leaders in school mathematics are essential for improving the mathematical knowledge and pedagogical competence of the staff, for providing information about mathematics instruction within the school and between the school and its feeder schools, and for assuring the implementation of a comprehensive, high-quality program. Such leaders give assistance and support to teachers and administrators in promoting excellence in mathematics for all students.

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For these reasons, the National Council of Teachers of Mathematics recommends that every secondary school identify a mathematics leader, often called the department head, to provide ongoing leadership and assistance in planning, implementing, and evaluating a comprehensive mathematics program. The mathematics leader must have an in-depth understanding of mathematics and a thorough knowledge of, and competence in, effective teaching methodology, coupled with the ability to work well with others. Such a person would be available at the building level to provide leadership in matters concerning (a) curriculum, (b) methodology and materials, (c) student assessment, (d) professional development, and (e) procedural duties.

Specifically, the mathematics leader should provide leadership and assistance to teachers, principals, supervisors, and other administrators in the following ways:

1. Curriculum
   a) Fostering the development, implementation, evaluation, and updating of departmental goals and objectives
   b) Coordinating the implementation of an effective instructional scope and sequence for mathematics
   c) Contributing toward the development of course offerings to meet diverse student needs
   d) Facilitating the review and revision of curricula to incorporate new developments in mathematics education
   e) Encouraging the integration of mathematics with other content areas
   f) Providing curriculum articulation between schools and among grade levels
   g) Assuring consistent standards among teachers and among courses
2. Methodology and Materials
   a) Acquainting teachers with successful and innovative strategies for classroom instruction through demonstration lessons and conferences
   b) Helping teachers select and implement activities that improve students' motivation and attitude toward mathematics
   c) Facilitating the review and selection of textbooks
   d) Making recommendations for the acquisition of teaching resources such as manipulative materials, calculators, computers, computer software, and other instructional media
3. Student Assessment
   a) Participating in the review and selection of assessment techniques
   b) Assisting teachers in the design and implementation of all forms of assessment
   c) Helping teachers interpret and use assessment data
   d) Working with the guidance staff to facilitate appropriate student placement
4. Professional Development
   a) Encouraging teachers to pursue further study of the mathematical sciences
   b) Providing information about innovative materials and teaching strategies recommended by the mathematics education community
   c) Encouraging teachers to become participating members in professional mathematics organizations
   d) Facilitating the attendance of teachers at professional meetings and conferences
   e) Encouraging discussion of the professional literature in mathematics education and related fields
5. Procedural Duties
   a) Orienting new teachers
   b) Assisting substitute teachers and student teachers
   c) Conducting departmental meetings
   d) Participating in the development of the master schedule
   e) Formulating the departmental budget
   f) Participating in the recruitment and selection of mathematics teachers
   g) Facilitating students' participation in competitions and special programs

For the mathematics leader to accomplish the expected tasks, it is recommended that school systems provide a monetary supplement, released time, sufficient support services, and the opportunity to participate in professional activities in mathematics education at the local, state/provincial, regional, and national levels. The school mathematics leader is a critical component of an effective mathematics instructional program. The need for strong leadership at the building level is not merely desirable, it is essential. (April 1988)

Metrication

Measurement is a common daily activity performed in all nations, and a knowledge of its concepts and skills is an important topic for all sectors of society. On an international level, the increased demand for a common language of measurement has been eased by the adoption of the metric system. The teaching of this system of measurement is not the sole responsibility of mathematics teachers, however; all teachers and administrators share the responsibility to prepare students for a world where the metric system of measurement prevails. Yet, many in education, including mathematics education, continue to ignore the teaching and learning of the metric system.

As a part of the mathematics program, metric education provides models for activities involving numeration, decimal concepts, and estimation. It serves as a link that joins measurement concepts and skills to other major topics in the school mathematics curriculum. Therefore, the National Council of Teachers of Mathematics supports the use of the metric system as an integral part of the mathematics curriculum at all levels of education and recommends that all educators assume responsibility for providing leadership and direction in metric education. (April 1986)

Professional Development of Teachers of Mathematics

Professional development in the complex context of school mathematics teaching is the open-ended process of teacher learning: learning mathematics and about mathematics; learning about students and how they learn, individually and in the social setting of school; learning the craft of teaching. Against the backdrop provided by *Curriculum and Evaluation Standards for School Mathematics* (1989), *Professional Standards for Teaching Mathematics* (1991), and *Assessment Standards for School Mathematics* (1995), teacher professional development must also include learning new ways to support the development of mathematical power in all students. The National Council of Teachers of Mathematics asserts that teachers of mathematics must engage in professional development activities that support teacher learning along each of these dimensions, throughout their careers, if the vision of classrooms outlined in its *Standards* documents is to be realized.

Professional development occurs in many ways. For example, teachers engage in professional development when they build their knowledge base and examine their own beliefs and assumptions through investigating and evaluating the curriculum materials, classroom structures and patterns of interactions with and among students, and varied means of student assessment. By solving the problems, managing the conflicts and dilemmas of practice in an era of reform, teachers construct their own professional development programs. The Council supports these efforts in a variety of ways, including the publication of professional journals and educational materials, and sponsoring regional and national conferences.

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However, teachers should not be expected to bear the burden of professional development through their own individual work in isolation. Teachers much be provided with sustained opportunities to collaborate with colleagues, to share and critique ideas, to draw on the knowledge and perspectives of others, to assume a reflective and analytic stance within a professional community.

Teacher collaboration may take many forms. Within schools, teams of teachers might focus on the design of particular courses, on curriculum articulation across grade levels, or on testing new teaching strategies or technology. Collaboration with higher education could include continued study of mathematics, support by experienced teachers of prospective teachers, or engagement in classroom-based research. Teachers from different schools can work together to coordinate district mathematics programs across grades K–12. They can also collaborate through membership in professional organizations, or through participation in curriculum dissemination projects. The Council supports these activities through its publications and conferences, and through such other activities as its support of Affiliated Groups.

Whatever the specifics, certain themes will run through all effective professional development programs. First, the focus of effective programs will be on teachers' needs as they work to enhance the learning of all students, including students from groups typically underrepresented in classes beyond arithmetic, in the context of classrooms and schools and communities in which they reside. Second, effective programs will recognize that the needs of teachers evolve over time as they move from prospective teachers to new teachers to experienced teachers. Third, programs will involve teachers themselves in the identification of these needs and in the design and conduct of professional development programs. Fourth, programs will be informed by the most current knowledge of effective practice and ways to achieve it, and will also contribute to that knowledge. Finally, effective programs will recognize that meaningful engagement by teachers in sustained professional development requires adequate long-term financial and structural support.

Responsibility for the continued transformation of school mathematics rests, ultimately, with classroom teachers. To shoulder the responsibility teachers must have access to ongoing, informed, carefully and creatively designed professional development opportunities. The Council supports the growth of mathematics teachers by providing a range of professional development opportunities; developing and updating standards for the quality of these opportunities; and furthering professional development efforts through dissemination of effective models. The Council also encourages and supports the professional development opportunities provided by schools, districts, higher education, and other professional organizations. (September 1996)

Professional Standards for Selection and Implementation of Instructional Materials

The content, organization, and style of instructional materials, particularly basal textbooks, are among the most important factors influencing outcomes of school mathematics programs. Thus, the process of selecting new textbooks and ancillary materials is a critical step in planning curricula and preparing for instruction. This process includes setting criteria, screening materials, making choices, and implementing the new program. Although teachers and students are vitally concerned with the quality of the instructional materials they must use, the selection and preparation for use of those materials are often constrained by inappropriate selection and implementation processes.

In order to improve curriculum and instruction in elementary and secondary mathematics programs, the National Council of Teachers of Mathematics has adopted the following standards for selecting instructional materials and implementing programs using those materials. The Council urges compliance with these standards by all school districts.

Standard 1: The Review and Selection Committee

The entire process of instructional materials selection should be led by teachers and supervisors with expertise and responsibility in mathematics education. Except in the most unusual circumstances, the recommendations of the committee must be followed.

Membership on the Review and Selection Committee should include, but not necessarily be limited to, classroom teachers representing the grades or courses for which instructional materials are being selected as well as teachers in grades or courses that precede or follow the target courses; mathematicians or mathematics educators with knowledge of content, curriculum, and pedagogical trends covering the full spectrum of K–12 mathematics and beyond; and school administrators who have overall responsibility for supporting and guiding the implementation of new programs.

Selection of committee members must be made in consultation with a person having expertise and responsibility in mathematics education. Whoever is chosen should be a full working member. Where the talents of a school or district mathematics staff cannot fulfill the roles described above, appropriate outside consultants should be obtained.

Standard 2: Criteria for Selection of Instructional Materials

Criteria for selection must be defined and made public prior to the review process.

The criteria should identify the desired instructional approach as well as the mathematics content. Criteria for selection should be based on program needs which can be identified by:

- evaluation of the present program, including analysis of student achievement, attitudes and learning characteristics, and a survey of teacher opinions;
- current research on the teaching and learning of mathematics;
- recommendations of professional organizations; and
- curriculum guidelines of local, state or provincial, and national governments.

Difficulties in implementation should be considered only if they seem insurmountable. Any adoption of new instructional materials will create some problems of implementation. However, the committee's goal should be the identification of the best possible program, not the easiest to implement.

Copyright dates and formula-determined reading levels are generally inappropriate as selection criteria. Although fashions in content and pedagogy change, a newer (or older) copyright does not assure higher quality. Because of the large technical vocabulary associated with mathematics, results of standard readability formulas should be used with extreme caution.

Standard 3: The Review of Instructional Materials

The Review and Selection Committee should actively seek materials from a variety of sources and evaluate the materials on the basis of the previously defined criteria.

The process of identifying, collecting, and examining material for potential adoption takes time to be done well. Time for committee members to do their work must be made available by the school system.

The committee should consult the following sources to identify appropriate instructional materials:

- critical reviews in professional journals;
- recommendations of teachers and supervisors in the district and in nearby districts with similar characteristics and goals;
- recommendations or authorizations of state or provincial committees where they exist;
- independent information bases such as the National Diffusion Network; and
- representatives of all publishers of appropriate material.

Instructional materials developed by not-for-profit organizations as well as commercial publishers should be considered. Whenever possible, committee representatives should examine materials displayed at a national or regional NCTM meeting. Interviews with members of the author team or a publisher's representative may also be helpful.

Once the materials for review have been collected, each should be evaluated for:

- content coverage and development of each major curricular strand;
- development of the full range of cognitive abilities, especially problem solving and analysis;
- correlation of the content with local, state or provincial, or national scope-and-sequence guidelines;
- correlation of the content and instructional approach with research on mathematics teaching and learning;
- correlation of the content and instructional approach with the standards of mathematics professional organizations;
- correlation between textual features and characteristics of special students;
- evidence of success based on publishers' field validation studies, implementation in other districts, critical reviews in professional journals and reports, or local field testing where possible; and,
- representation of the diversity of national social, political, and economic life.

Since instructional materials comprise a small fraction of any school's budget, the cost of the materials should not be a factor. Potential financial savings do not justify the selection of less desirable materials. Where textbooks are accompanied by ancillary materials, however, it is important to assess the extent to which successful use of the text depends on such extra materials.

Standard 4: Implementation of New Instructional Materials

The selection of new instructional materials must be only part of a careful curriculum development process that includes appropriate inservice preparation for teachers and supervisors and a formal evaluation of the new program's effectiveness.

In-service preparation should acquaint all teachers with the general program goals and the emphasis for each topic in every course. This emphasis should, where possible, be identified in terms of the appropriate number of instructional days to be devoted to each topic, and the topics should be correlated with specific portions of the new instructional materials. In-service should provide the additional mathematics background and preferred instructional approaches to the mathematics content.

Implementation should include periodic evaluation surveys of teachers' and students' reactions to the materials as well as an analysis of student achievement. Results of these evaluations should be used to evaluate the achievement of the program goals and plan for ongoing modification of the program. Implementation is typically more successful when such in-service support continues throughout the academic year.

Standard 5: Professional Integrity

The instructional materials selection process must not allow influences that compromise the professional integrity of the process.

Any person connected with the process of selection and implementation of instructional materials who has a financial interest in any program being considered must make that interest known publicly at the outset. For the duration of the selection process those involved must not accept gifts of travel, entertainment, or materials from a vendor.

The instructional materials recommended by the Selection Committee must be adopted unless irregularities in the selection process are documented. (April 1984)

Research in Mathematics Education

Significant improvements in the teaching and learning of mathematics result from the systematic development of research-based knowledge. Such knowledge is relevant to the needs of all persons associated with mathematics education. For example, research that investigates classroom practices benefits students and teachers. Research that suggests directions for programs and policy decisions provides guidance to administrators, supervisors, and curriculum developers. Research that promotes understanding of teacher development benefits teacher educators and preservice teachers. Research that clarifies our understanding of basic learning principles benefits everyone.

Classroom teachers, supervisors, mathematicians, teacher educators, and curriculum developers can all play important roles in the research process. For example, classroom teachers can identify pertinent issues for research and contribute to their investigation; mathematics supervisors and teacher educators can communicate research findings to inservice and preservice teachers; and curriculum developers can implement research findings in the preparation of student and teacher instructional materials.

Gains in research-based knowledge are made when mathematics educators are aware of pertinent research in other disciplines and collaborate with researchers in these disciplines. But, it is the mathematics educators themselves, trained in the content of mathematics and methods of teaching it, who must assume leadership roles in conceptualizing, communicating, and implementing research related to mathematics instruction.

The National Council of Teachers of Mathematics (NCTM) affirms the central role of research in the teaching and learning of mathematics. NCTM therefore supports research in mathematics education and promotes efforts to communicate the findings and implications of such research. Furthermore, NCTM encourages all mathematics educators to be involved in activities related to research. (September 1990)

Teaching Mathematics in the Middle Grades

The National Council of Teachers of Mathematics advocates that all middle-grade teachers of mathematics have extensive preparation in mathematics and its pedagogy. The new vision of school mathematics and mathematics teaching presented in the *Curriculum and Evaluation Standards for School Mathematics* and the *Professional Standards for Teaching Mathematics* requires that mathematics teachers be responsible for:

- selecting and developing worthwhile mathematical tasks;
- managing, enhancing, and promoting discourse in the classroom;
- creating a learning environment that fosters students' confidence in their own ability and skill in problem solving, communicating with and about mathematics, and reasoning;
- engaging in ongoing analysis of teaching and learning;
- accommodating the characteristics and needs of young adolescents;
- working with other teachers as a team to develop interdisciplinary and developmentally appropriate mathematics programs;
- modifying the mathematics curriculum to motivate and nurture students with different abilities and learning styles;
- interacting sensitively with students and parents from diverse racial and cultural backgrounds.

The NCTM believes that every student has the right to a mathematics education that ensures that he or she achieves mathematical literacy and develops the concepts, skills, and dispositions necessary for a meaningful and productive life. Middle-grade students in particular are at a critical stage when the attitude they develop toward mathematics can have a significant impact on their chances for success in high school mathematics and on their life choices. It is therefore essential that mathematics teaching in the middle grades help students experience mathematics as a personally meaningful and worthwhile endeavor. Furthermore, students should see mathematics as a powerful and useful tool in their lives, in their pursuit of knowledge in other subject areas, and in their careers.

If we are to reach these student goals, teachers of middle-grade

mathematics should have high-quality preparation in mathematics and mathematical pedagogy as outlined in the "Professional Development of Teachers" section of the *Professional Standards for Teaching Mathematics*. Schools have a responsibility to assure through their hiring and professional development practices that children's mathematical experiences are with teachers who possess the knowledge and characteristics described therein.

Teacher education and mathematics faculties must align their teacher preparation and professional development programs with these *Standards*. Certification options available through state and provincial departments of education should include middle-grade mathematics. Schools, school districts, colleges, universities, and provincial or state licensing agencies are encouraged to collaborate in designing and implementing undergraduate, in-service, and graduate programs that will enable middle-grade teachers of mathematics to teach for the present and future demands of society in accordance with the developmental needs of the students. (March 1992)

The Use of Technology in the Learning and Teaching of Mathematics

Technology is changing the ways in which mathematics is used and is driving the creation of new fields of mathematical study. Consequently, the content of mathematics programs and the methods by which mathematics is taught and learning assessed are changing. The ability of teachers to use the tools of technology to develop, enhance, and expand students' understanding of mathematics is crucial. These tools include computers, appropriate calculators (scientific, graphing, programmable, etc.), videodisks, CD-ROM, telecommunications networks by which to access and share real-time data, and other emerging educational technologies. Exploration of the perspectives these tools provide on a wide variety of topics is required by teachers.

It is the position of the National Council of Teachers of Mathematics that the use of the tools of technology is integral to the learning and teaching of mathematics. Continual improvement is needed in mathematics curricula, instructional and assessment methods, access to hardware and software, and teacher education.

- Although the nature of mathematics and societal needs are forces that drive the curriculum, the opportunities that technology presents must be reflected in the content of school mathematics. Curricular revisions allow for the de-emphasis of topics that are no longer important, the addition of topics that have acquired new importance, and the retention of topics that remain important. In the implementation of revised curricula, time and emphasis are to be allocated to the topics according to their importance in an age of increased access to technology. Instructional materials that capitalize on the power of technology must be given a high priority in their development and implementation. The thoughtful and creative use of technology can greatly improve both the quality of the curriculum and the quality of students' learning.
- Teachers should plan for students' use of technology in both learning and doing mathematics. A development of ideas is to be made with the transition from concrete experiences to abstract mathematical ideas, focusing on the exploration and discovery of new mathematical concepts and problem-solving processes. Students are to learn how to use technology as a tool for processing information, visualizing and solving problems, exploring and testing conjectures, accessing data, and verifying their solutions. Students' ability to recognize when and how to use technology effectively is dependent on their continued study of appropriate mathematics content. In a mathematics setting, technology must be an instructional tool that is integrated into daily teaching practices, including the assessment of what students know and are able to do. In a mathematics class, technology ought not be the object of instruction.
- Every student is to have access to a calculator appropriate to his or her level. Every classroom where mathematics is taught should have at least one computer for demonstrations, data acquisition, and other student use at all times. Every school mathematics program should provide additional computers and other types of technology for individual, small-group, and whole-class use. The involvement of teachers by school systems to develop a comprehensive plan for the ongoing acquisition, maintenance, and upgrading of computers and other emerging technology for use at all grade levels is imperative. As new technology develops, school systems must be ready to adapt to the changes and constantly upgrade the hardware, software, and curriculum to ensure that the mathematics program remains relevant and current.
- All professional development programs for teachers of mathematics are to include opportunities for prospective and practicing teachers to learn mathematics in technology-rich environments and to study the use of current and emerging technologies. The preparation of teachers of mathematics requires the ability to design technology-integrated classroom and laboratory lessons that promote interaction among the students, technology, and the teacher. The selection, evaluation, and use of technology for a variety of activities such as simulation, the generation and analysis of data, problem solving, graphical analysis, and geometric constructions depends on the teacher. Therefore, the availability of ongoing in-service programs is necessary to help teachers take full advantage of the unique power of technology as a tool for mathematics classrooms.

The National Council of Teachers of Mathematics recommends the appropriate use of technology to enhance mathematics programs at all levels. Keeping pace with the advances in technology is a necessity for the entire mathematics community, particularly teachers who are responsible for designing day-to-day instructional experiences for students. (February 1994)

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